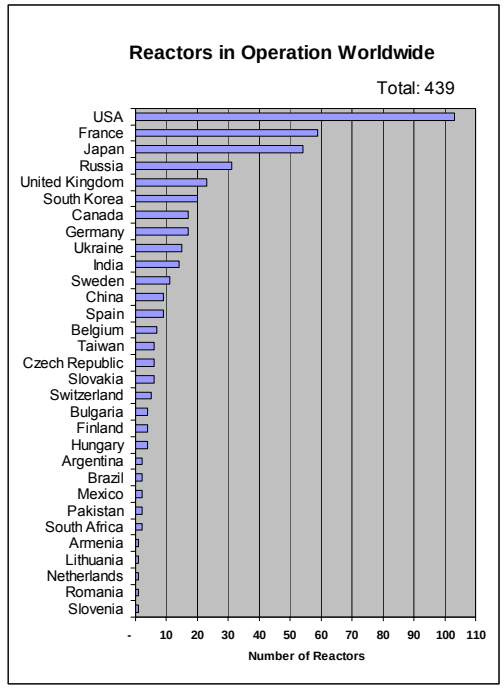
Nuclear Power:
The Situation Today
and Prospects for the Future

Office of Nuclear Energy, Science and Technology
U.S. Department of Energy

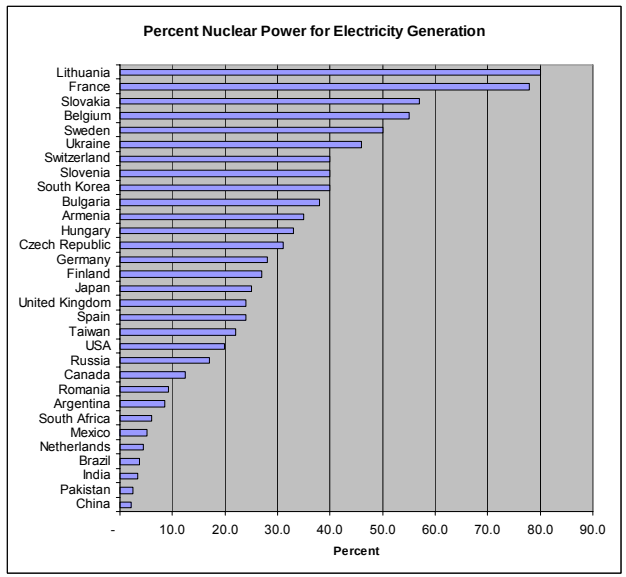
August 16, 2005

Worldwide View: Commercial Power Plants

- **Worldwide, 31 countries are operating 439 nuclear plants for electricity generation**
  - Total net installed capacity of 366 GWe
  - Represents 16% of the world's electricity generation
- **Almost half of the world's power reactors are in the U.S. (103 units/98 GWe), France (59 units/63 GWe), and Japan (54 units/46 GWe)**
- **Lithuania, France, Slovakia, Belgium, and Sweden rely on nuclear power for at least half of their electricity.**



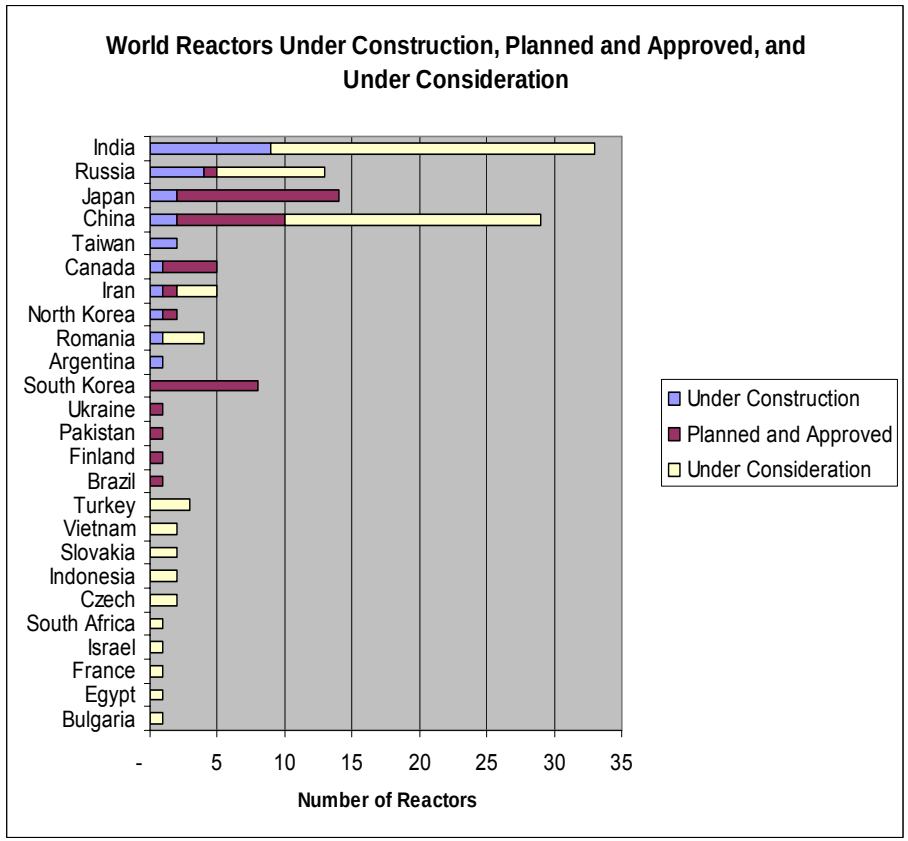
Source: World Nuclear Association



Source: World Nuclear Association

Reactors Under Construction, Planned and Approved, and Under Consideration

- **Worldwide, 10 countries are constructing 24 nuclear power units.**
- **Eleven countries are planning to construct 39 more nuclear power units.**
- **Fifteen countries are considering whether to construct 73 more nuclear power units.**
- **If all these 136 units are constructed, world nuclear capacity will increase from 366 GWe today to 484 GWe, a 30 percent increase.**



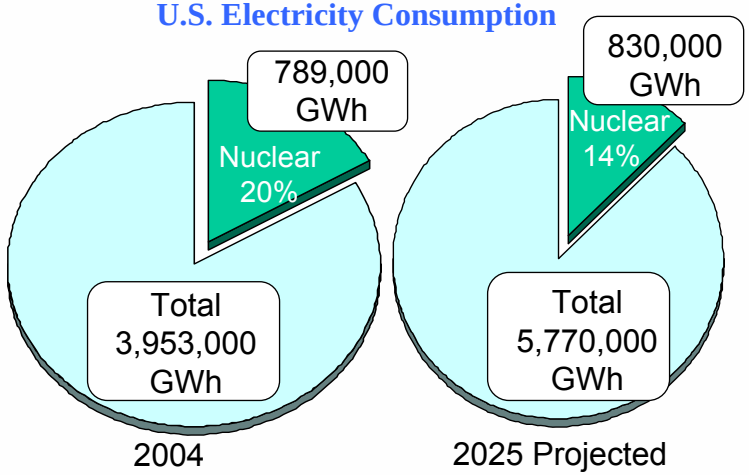
Source: World Nuclear Association

- **These 136 units are needed to maintain nuclear energy's 16% share of the energy mix in 2025.**

The Outlook for Nuclear Power Without New Builds in the United States

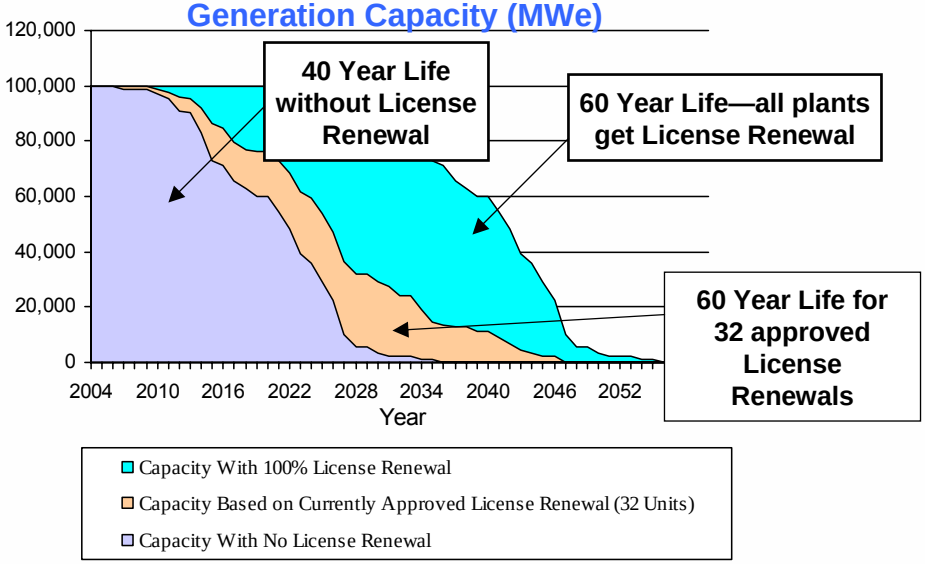
- **License renewal (allowing a 60-year operating life) has been approved for 32 of the 103 nuclear units; applications have been submitted for 16 additional units.**
  - Even after license renewal, without new construction, U.S. nuclear capacity will fall off rapidly in the mid-2030s and be non-existent by 2056.

U.S. Electricity Consumption



Source: Energy Information Administration

Projected Fall-off in Nuclear Generation Capacity (MWe)



Source: Nuclear Regulatory Commission Data

- **Projected electricity demand**
  - EIA forecasts the U.S. will need 281gigawatts of new generating capacity by 2025.
  - This is the equivalent of building one new 400 megawatt natural gas plant every week-and-a-half over the next twenty years.
  - Nuclear power capacity will increase only due to uprates of currently operating plants and the TVA Browns Ferry 1 restart.

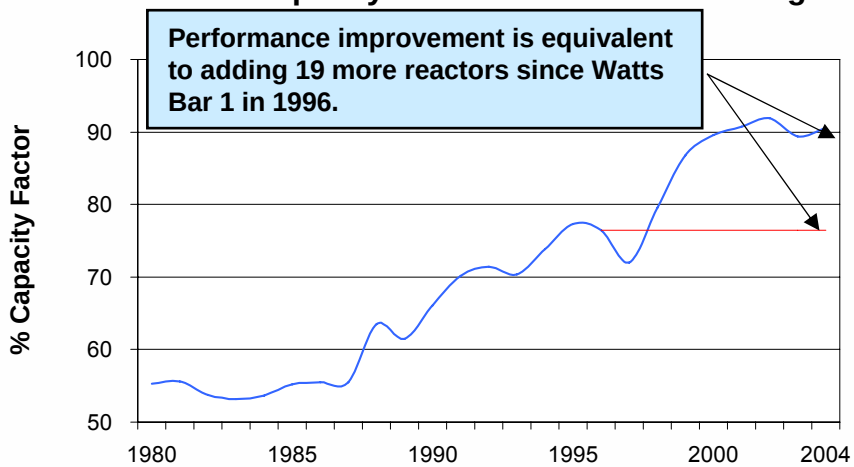
National Commission on Energy Policy

- **December 2004: "Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges"**
- **Nuclear Benefits**
  - **The crucial challenge of capping and ultimately reducing U.S. and world greenhouse gas emissions would be considerably more difficult without the contribution that expanding nuclear electricity generation could make to this task.**
  - **Uranium to fuel an increased number of reactors is abundant and relatively inexpensive, both in the United States and worldwide. The uranium-supply situation is such that the availability and cost of this fuel are not likely to fall prey to cartels, embargoes, political instability, or terrorist acts.**
  - **Expanded use of nuclear energy would alleviate pressure from the electricity-generation sector on natural-gas supplies, helping to constrain increases in natural-gas prices and freeing up gas for non-electricity applications with benefits in terms of conventional pollution, greenhouse-gas emissions, and energy security.**
  - **Experience with nuclear power plants in the United States and elsewhere over the past decade and more has demonstrated that these plants can be operated with high degrees of reliability and safety and extremely low exposures of workers and the public to radiation.**

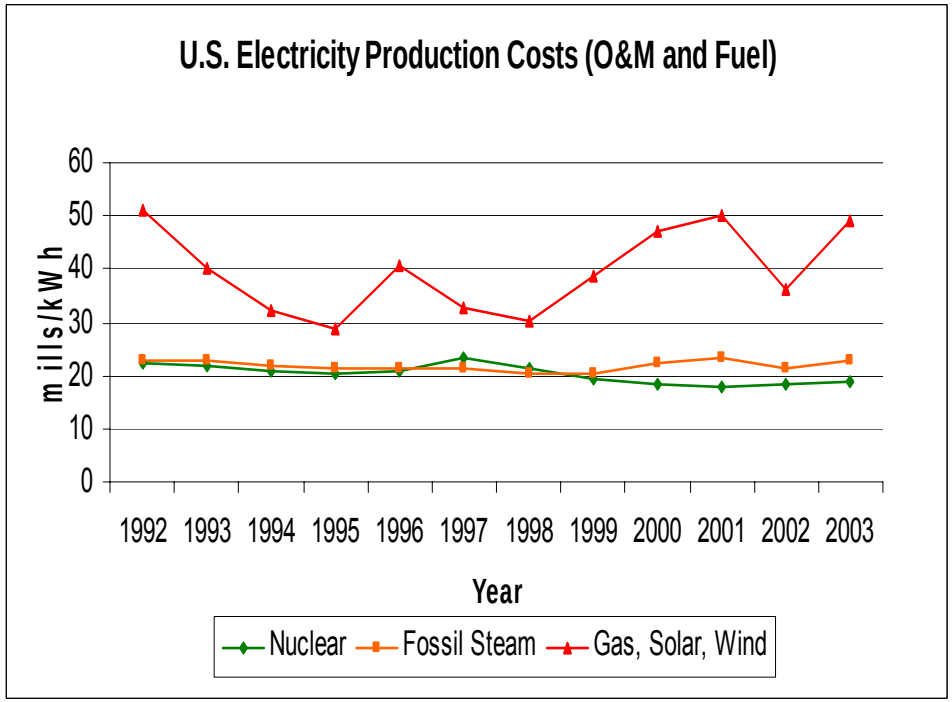
Steady Improvements Over The Past 20 Years Have Been Essential to Energy Security and Emissions Avoidance

- **Excellent plant management and operational experience**
- **Well-developed safety culture and effective regulation**
- **Lowest production costs for fueled-generation**
- **Accounts for more than 2/3 of U.S. emission-free generation**

Nuclear Capacity Factor is at an All-Time High



Source: Nuclear Energy Institute



Source: Energy Information Administration

Electricity production costs do not include capital. For new plant construction, add at least 20 - 30 mills/kW-hr to cover capital investment for both nuclear and coal.

NCEP Identified Obstacles to Expanding Nuclear Power

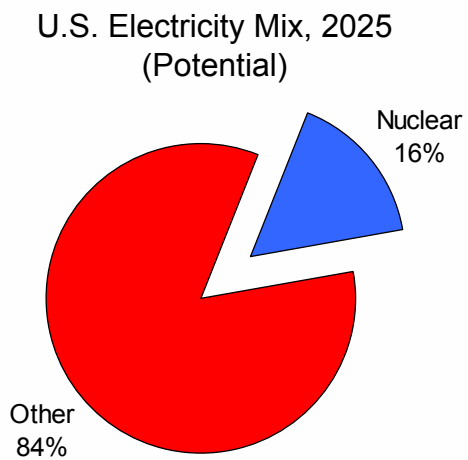
- **Cost**
  - **Although nuclear power was at a time less competitive, its economy has improved with the increase in the price of natural gas and coal.**
  - **Nuclear plant standardized and simplified designs are also key.**
- **Accidents and Terrorist Attacks**
  - **Nuclear power reactors of contemporary design have compiled an excellent safety record. If the number of nuclear reactors in the U.S. doubles or triples over the next 30 to 50 years, and the number worldwide grows ten-fold— as would be needed to have a large impact on greenhouse gas emissions — the probability of a major release of radioactivity should fall a further ten-fold or more.**
  - **Improved defenses against terrorist attack, as well as against malfunction and human error, can probably be achieved, in part, through advanced reactor designs that rely more heavily than those of the past on passive mechanisms for heat removal.**
  - **The biggest challenge will be to achieve these improvements while simultaneously reducing rather than increasing the costs of reactor construction and operation.**

NCEP Identified Obstacles to Expanding Nuclear Power (cont.)

- **Radioactive Wastes**
  - **Potential nuclear plant owners and the public need to be persuaded that the Government is able to meet its obligation, under existing law, to take possession of and adequately sequester the highly radioactive spent fuel from reactor operations.**
  - **Certifying, licensing, and beginning to operate the geologic repository at Yucca Mountain, Nevada, presents difficulties.**
- **Proliferation Risks**
  - **The expanded use of nuclear energy in the U.S. and abroad should be accomplished in a way that minimizes the potential contributing factors to nuclear weapon proliferation.**

Nuclear Power's Potential in the United States

- **To maintain a 20% mix in 2025, it would be necessary to add 39 GWe of new nuclear capacity over and above EIA projected uprates of current plants by 2025.**
- **To reach a level of 39 GWe by 2025, it would be necessary to bring new nuclear plants online at a rate of about 3 to 4 per year starting in 2015.**
- **This rate of building, while not impossible, would be difficult to achieve in so short a time window.**
  - If the first new reactors do not come online until 2014 – 2018, we might be able to assume that 10 additional GWe online would be achievable by 2025.
  - Nuclear would be 16% of the mix.



Source: DOE/NE

Nuclear Power's Potential in the United States (cont.)

- **Assuming demand for electricity continues to grow at the same rate between 2025 and 2030 as it is projected by EIA to grow between 2020 and 2025, then—**
  - To get back up to a 20% mix by 2030, it would be necessary to add more than 50 GWe of new nuclear capacity.
  - If we only build 10 GWe of new nuclear capacity by 2025, it would be necessary to build new nuclear plants at a rate of 8 per year after that.
- **To proportionally maintain the environmental and sustainability benefits of nuclear power, we will need to build a substantial amount of new nuclear capacity.**

NCEP Addressing the Obstacles to Expanding Nuclear Power

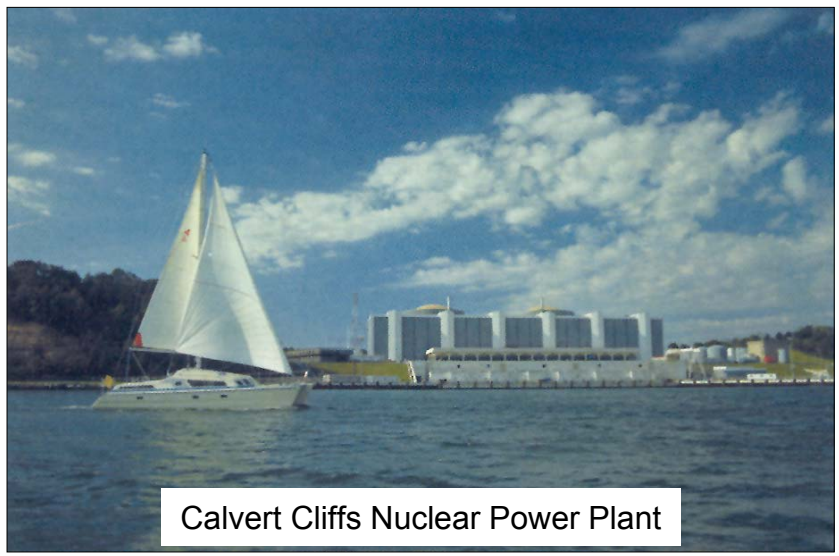
- **Key Recommendations**
  - Fulfill existing federal commitments on nuclear waste management.
  - Provide $2 billion over ten years from federal energy research, development, demonstration, and deployment budgets for demonstration of one to two new advanced nuclear facilities.
  - Significantly strengthen the international non-proliferation regime.

NCEP Addressing the Obstacles to Expanding Nuclear Power (cont.)

- **Other Recommendations**
  - The Federal government should treat new nuclear power capacity in the same manner as renewable capacity if portfolio standards are adopted.
  - License renewal of existing plants should be contingent on meeting usual safety criteria and ability to adequately resist a terrorist attack.
  - Treatment of the Nuclear Waste Fund should be reformed; it should not be "scored" within the budget.
  - The Department should renew it offer to Nevada to negotiate an appropriate benefits package.
  - The Department should continue to engage stakeholders on waste management issues, particularly on waste transport.
  - The Federal government should establish a project for centralized, interim spent fuel storage at no fewer than two U.S. locations.
  - The U.S. should continue indefinitely its moratoria on commercial reprocessing and construction of breeder reactors, and become more active in its discouragement of the accumulation of separated plutonium in civil fuel cycles.
  - The Federal government should continue to support R&D on advanced reactor and fuel cycle concepts leading to lower costs, reduced waste management burdens, and higher proliferation barriers in comparison with current reprocessing and breeding technologies.

Nuclear Power 2010
Benefits and Costs

- **The currently operating 103 nuclear power plants in the U.S. are avoiding the emissions of as much as 600 million metric tons of CO_2, 1,500,000 short tons of NOx, and 2,500,000 ST of SO_2.**
- **Every GWe of new nuclear capacity will save about 6 MMT CO_2, nearly 15,000 ST NOx, and 25,000 ST SO_2 annually.**
- **Building 50 GWe of new nuclear capacity by 2030 would save about 300 MMTCO_2, 750,000 ST NOx, and over 1 million ST SO_2 annually.**
- **Using the NCEP's recommendations to establish a mandatory, economy-wide tradable-permits program to limit greenhouse gas emissions while capping initial costs at $7 per metric ton of CO_2-equivalent reduction, the carbon dioxide emissions saved by 50 GWe of new nuclear capacity would have an annual equivalent value of more than $2 billion.**
- **The combined private/public cost of the NP2010 program is estimated to be around $1 billion.**

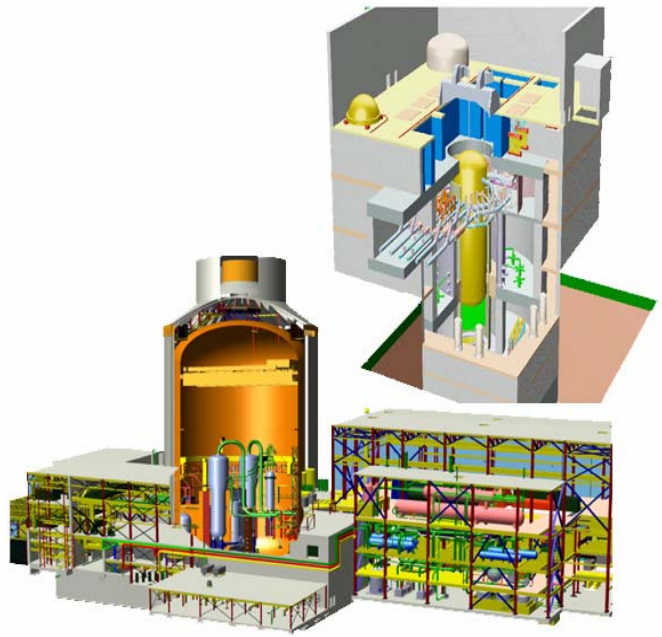

Calvert Cliffs Nuclear Power Plant

Nuclear Power 2010

Working with Industry to Build New Nuclear Plants

- **Exploring sites for new nuclear plants**
- **Demonstrating key untested regulatory processes**
  - Early Site Permit (ESP)
  - Combined Construction and Operating License (COL)
- **Developing new light water reactor designs**
  - Design Certification for new technologies
  - First-of-a-kind engineering for new standardized nuclear plant designs
- **Developing concepts to mitigate financing risks**

ESBWR



AP-1000

Program Goal	*Pave the way for an industry decision to build at least one new advanced light water reactor nuclear plant in the United States that would begin operation early in the next decade.*

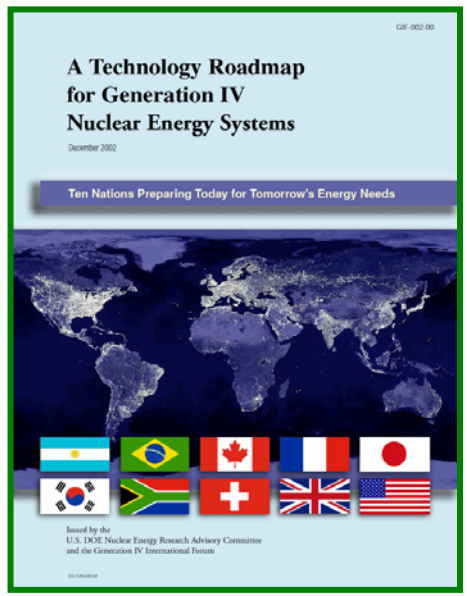
Nuclear Power 2010

The NCEP Challenges

- **By supporting the development of new standardized designs that will have reduced construction and operations and maintenance costs, NP 2010 will reduce the cost of future nuclear power generation.**
- **The advanced light water reactor designs that are supported by NP 2010 are “evolutionary” rather than “revolutionary.” The non-cost NCEP challenges are better addressed by the Generation IV and Advanced Fuel Cycle Initiative programs.**

Generation IV Technologies

- **Two-year international roadmapping effort with more than 100 experts**
- **Six candidate Generation IV systems selected by the U.S.-led Generation IV International Forum and the U.S. Department of Energy's Nuclear Energy Research Advisory Committee for further development:**
  - Gas-cooled Fast Reactor (GFR)
  - Lead-cooled Fast Reactor (LFR)
  - Sodium-cooled Fast Reactor (SFR)
  - Molten Salt Reactor (MSR)
  - Supercritical Water-cooled Reactor (SCWR)
  - Very High Temperature Reactor (VHTR)
- **Roadmap identifies R&D needs for all six systems**
- **Crosscutting R&D needs**
  - Fuels, materials, energy conversion, design and evaluation methods



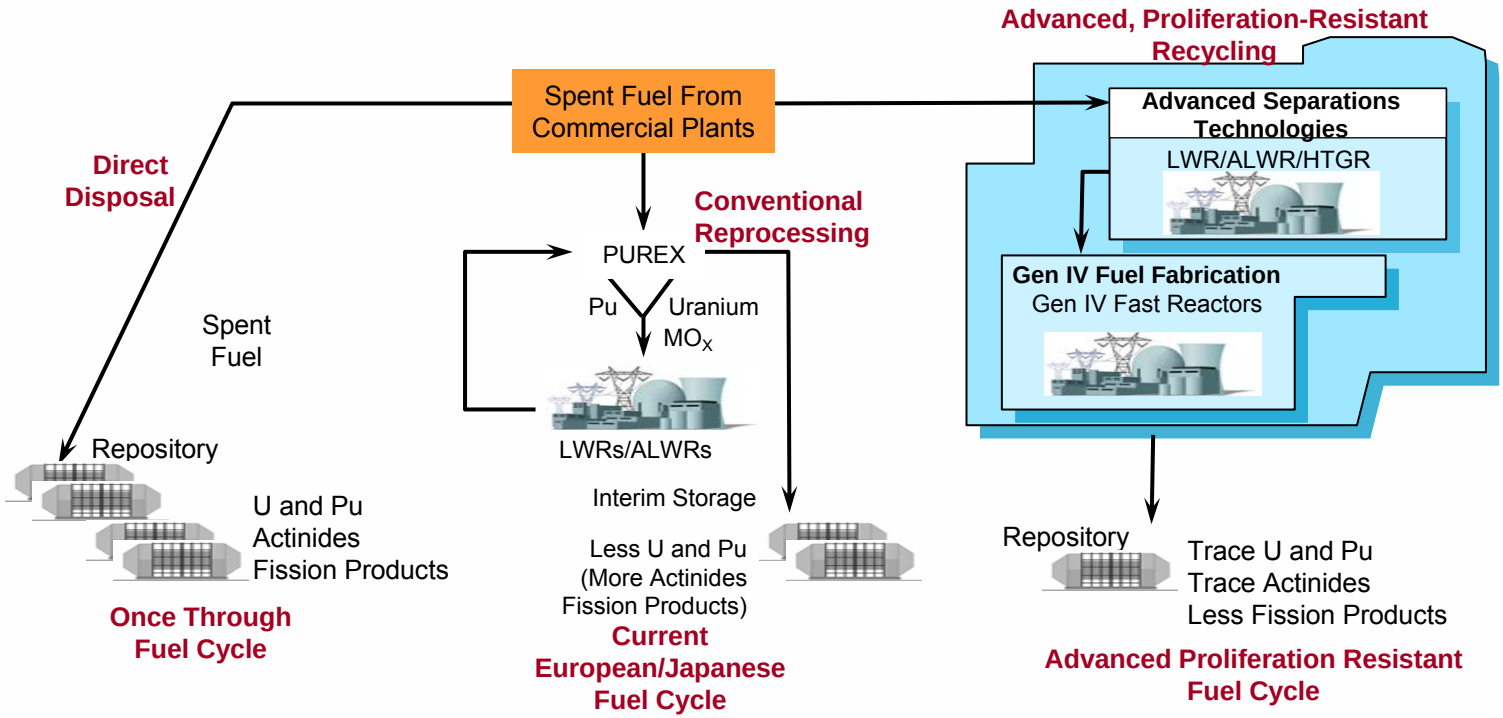
http://nuclear.gov/nerac/FinalRoadmapforNERACReview.pdf

Generation IV Technologies
Design Objectives

- **Sustainable**
  - Reduced waste production
  - Burn existing waste
  - Environmentally friendly—no greenhouse gases emitted
- **Economically Competitive**
  - Capital costs < $1K/kW
  - Operating cost < $0.015/kW-hr
- **Safe and Reliable**
  - Increased use of inherent safety features
  - Eliminate use of off-site response to emergency plant events
- **Proliferation Resistance and Physical Protection**
  - Plutonium never handled as pure element; always mixed with actinides

DOE's Advanced Fuel Cycle Initiative: Optimizing Spent Nuclear Fuel Disposition

- **Program Goals**
  - Delay or eliminate the need for a second repository
  - Develop a sustainable fuel source for nuclear energy



9 Repositories **7 Repositories** **1 Repository**

…if we maintain nuclear energy at 20% of U.S. electrical generation thru 2100

DOE's Advanced Fuel Cycle Initiative: Optimizing Spent Nuclear Fuel Disposition

Program Objectives

- **Develop fuel systems for Generation IV reactors**
- **Create fuel cycle technologies that:**
  - Reduce high-level waste volume
  - Reduce long-lived and highly radiotoxic elements
  - Reclaim energy content of spent fuel
  - Exhibit proliferation resistance

Prospects for New Nuclear Plants in the U.S.

- **Industry interest at highest levels since early 1980s**
  - Three major industry/government cooperative projects could lead to new nuclear plants in the near future
  - 10 nuclear utilities and two reactor vendors involved in project consortia
    - Utilities represent over 60% of the operating nuclear plants in the U.S.
  - Three power companies involved in NuStart consortium are looking to pursue sites and combined licenses independent of NuStart
- **Nuclear Regulatory Commission is actively engaged in current licensing actions and maintaining schedules**
- **Administration and Congress support deployment of new nuclear plants**
  - Support for Nuclear Power 2010
  - Energy legislation
- **Although new plants are being built overseas, many countries still look to the U.S. for leadership – U.S. leadership would accelerate the construction of many more plants overseas**